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# 3D TERRAIN GENERATION SUBSYSTEM[4]

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***Abstract:*** *The article reviews existing subsystems for generating 3D terrain. A comparative overview and analysis of the Unity, Unreal Engine, World Machine, Terragen, L3D3, Gaia systems was made. Their positive features and disadvantages are indicated. The need for the development of an own system is determined.*

*A comparative analysis of the mentioned virtual reality systems was made. For each of them, it is described what it is suitable for (what type of applications - games, systems with virtual reality, virtual worlds, virtual routes to existing maps and objects, simulation of natural phenomena and cataclysms with subsequent training of rescue teams, plug-in to other systems, etc.), what can be generated with it, how it can be used, and what it is not suitable for. Technologies and algorithms used are partially described.*

***Key words:*** 3D terrain generation*, Software Engineering, Information systems*.

## INTRODUCTION

3D terrain generation is relevant for applications in various fields: such as games, virtual reality, simulations, geographic information systems, architecture, and others.

Such subsystems - for generating 3D terrain - can be built in different ways, but the main goal is to generate a realistic terrain that meets the requirements of the specific application. This can be achieved by using various algorithms and methods, such as Perlin noise, Fractal noise, Voronoi diagrams, etc. To achieve a realistic terrain, it is important to take into account many factors, such as the topography of the area, the type of soil, various natural objects (mountains, rivers, forests and others). Therefore, it is necessary to use appropriate algorithms and methods for terrain generation.

In addition to terrain generation, the corresponding subsystem can have other functions, such as terrain optimization for better real-time performance, texture generation, adding various objects such as buildings, trees, animals, and others. To achieve better performance and efficiency of the subsystem, various optimization techniques can be used - dynamic leveling of terrain details, use of standardized data formats, and others.

When a project is implemented, it is important to conduct a detailed analysis of the requirements for the application being created and to define the specific functionalities that must exist and be used. This may include requirements for terrain visualization, terrain manipulation, interaction with other objects in the scene, real-time operation of the generator (ie - clearly defined requirements for the necessary hardware and software), possibilities to insert ready-made modeled components from other systems or previously stored patterns/components in files and others. The chosen system should allow for various necessary settings – turn on/off appropriate algorithms for different types of noise, realistic textures, visualizations, terrain manipulation modules, etc.

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## EXPOSITION

### 1. Unity

Unity is one of the most popular gaming platforms that is used to create computer games, simulations and virtual realities. Unity also includes a terrain generator that can be used to generate dynamic 3D terrains. Unity terrain generator uses various terrain generation algorithms such as Perlin noise, simplex noise, cellular noise and others. These algorithms are used to generate random numbers that are used to determine the height of points in the terrain (Fig. 1).

One of the most important aspects of the Unity terrain generator is the ability to generate different types of terrain, such as mountains, valleys, hills, plains, and more. It also provides the ability to change terrain generation parameters such as terrain height, terrain size, number of details, and more. The system can implement some of these features, such as using terrain generation algorithms similar to those used by the Unity terrain generator. Additionally, some of the terrain generation parameters can be used to change terrain height, size, and detail.

Similar to the Unity terrain generator, the system can generate different types of terrain, such as mountains, valleys, hills, plains, and more, depending on the chosen terrain generation algorithm. This makes it possible to create dynamic and realistic 3D terrains that can be used for different purposes.

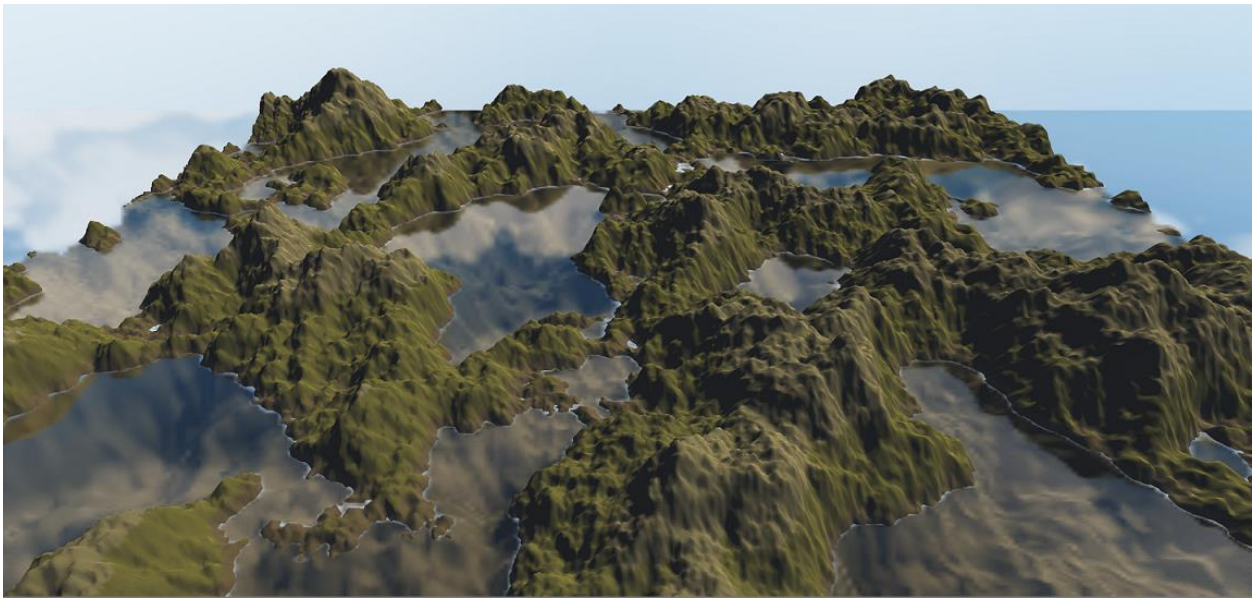

*Figure 1 – Unity terrain*

### 2. Unreal Engine

Unreal Engine is one of the most popular tools for developing PC games and virtual reality. It offers built-in 3D terrain generation tools that can be used to create complex game worlds and virtual spaces.

The Unreal Engine terrain generator uses a variety of methods to create realistic 3D terrains, including Perlin noise, fractal noise, and heightmaps. All these methods allow developers to generate terrains with different shapes and structures. Additionally, Unreal Engine offers a graphical terrain creation interface that allows users to build and edit terrains in real-time. This makes the terrain generation process easier and faster (Fig. 2).

Much can be learned from the terrain generator in Unreal Engine, including how to create realistic terrains using different generation methods and how to use the GUI to create and edit terrains in real-time. With this knowledge, better and more realistic terrains can be created.

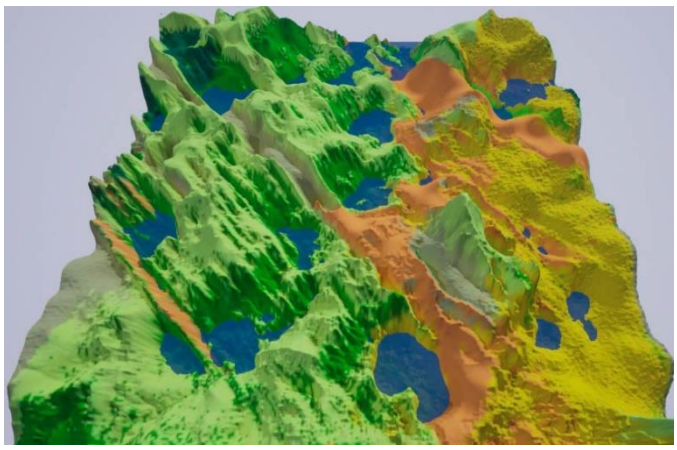

*Figure 2 – Unreal Engine terrain*

### 3. World Machine

World Machine is a software program specialized in generating realistic 3D terrains. It allows users to create and edit complex terrains using various generation methods such as Perlin noise, fractal noise, erosion, and more.

World Machine offers many different terrain generation tools, allowing users to create complex terrain systems with different textures, materials and effects. These tools are easy to use and allow users to create realistic terrains without deep knowledge of graphic design.

World Machine also offers the ability to export generated terrains in a variety of formats, including RAW, OBJ, TGA, and more. This makes the program extremely useful for users who work with various systems for computer games and virtual reality (Fig. 3).

Much can be learned from World Machine, including how to use different terrain generation methods and how to create complex terrain systems with different effects and textures. With this knowledge, more realistic and complex terrains can be created.

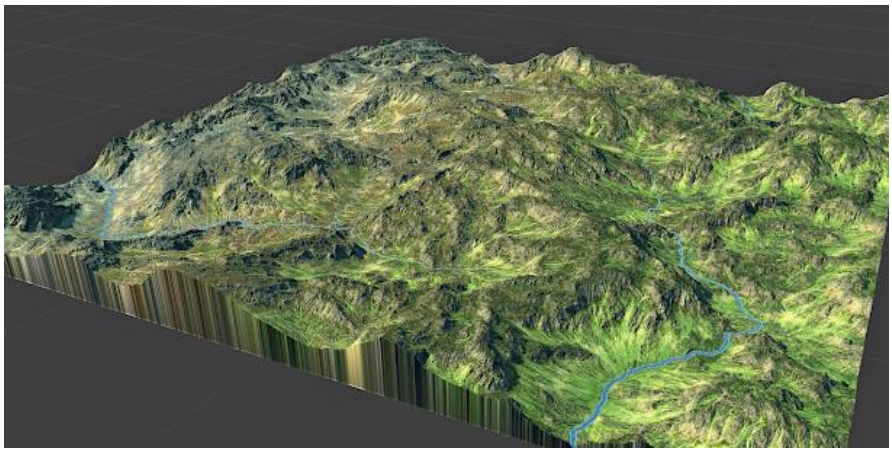

*Figure 3 – World Machine terrain*

### 4. Terragen

Terragen is another popular 3D terrain generation system. It was developed by Planetside Software and has been on the market since 1999. Terragen is used to create photorealistic images of landscapes and terrains for movies, TV commercials, animations, computer games and more.

Terragen uses complex mathematical modeling and simulation of natural phenomena, generating terrains by combining different methods of noise generation, textures and fast algorithms for rendering a large number of polygonal objects. The system allows the user to set various terrain parameters such as height, slope, shape and others. Terragen also includes a texture editor that allows you to create different effects such as snow, water, lava, and more. (Fig. 4).

Terragen is a very flexible system that allows users to import and export their projects in various formats such as OBJ, FBX, TGO, etc. This makes it possible to easily collaborate between different

programs and systems for generating 3D terrains. Terragen is very popular in visual effects environments for film and television, where a high degree of photorealism and landscape detail is required.

*Figure 4 – Terragen terrain*

## 5. L3DT

L3DT (Large 3D Terrain Generator) is software that allows users to create detailed and realistic 3D terrains. It is particularly useful for the gaming industry and for creating virtual worlds.

L3DT uses terrain generation algorithms such as Perlin noise and fractal Brownian motion, but also offers unique features such as generating rivers, lakes and mountains. Using L3DT, users can create large terrains with a lot of detail, making the software extremely useful for large games or creating virtual worlds.

Apart from terrain generation, L3DT also offers various terrain transformation tools, such as trenching, surface smoothing, etc. This makes the software also useful for architectural projects where it is important to have an accurate and realistic terrain (Fig. 5).

Although L3DT does not use machine learning algorithms to generate terrains, this software is extremely useful for generating detailed 3D terrains that can be used in games, virtual reality, architecture and other fields.

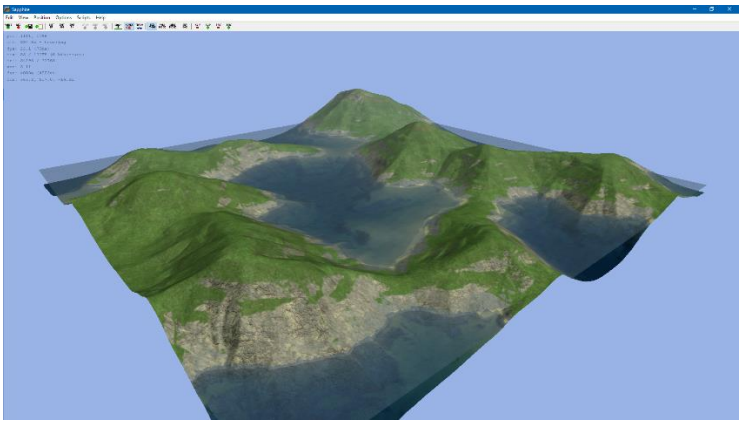

*Figure 5 – L3DT terrain*

## 6. Gaia

Gaia is a Unity plugin that allows users to generate and edit terrains on their Unity project. It is based on some of the most famous terrain generation algorithms, such as Perlin noise, voronoi diagrams, fractals and others. Gaia offers a graphical user interface that allows users to create and edit terrains in an easy and fast way.

Using Gaia, users can generate complex terrains that contain mountains, valleys, rivers, caves, and other natural features. The plugin has built-in features for creating cross roads, walking routes, etc. that can be easily added to the terrain. Gaia also offers the ability to add different plant species and other objects to the terrain that create a more realistic effect (Fig. 6).

One of the biggest advantages of Gaia is that it is very flexible and can be used to create different types of terrain. It also offers terrain optimization capabilities that can help speed up work with large terrains.

*Figure 6 - Giaia terrain*

**Unity Terrain Generator:**

Advantages:

1. Easy to use, with an accessible user interface;
2. Supports realistic terrains;
3. Allows editing of the terrain in real time;
4. Provides a wide selection of materials and textures.

Disadvantages:

1. Suitable for generating terrains on relatively small scales;
2. Requires constant contact with the Unity Engine.

**Unreal Engine Terrain Generator:**

Advantages:

1. Extremely powerful terrain generator suitable for large scales;
2. Provides multiple effects simulation capabilities;
3. Allows realistic reproduction of different types of terrain;
4. Unreal Engine built-in.

Disadvantages:

1. Complex to use and requires a higher level of knowledge and skills;
2. Requires powerful hardware equipment.

**World Machine:**

Advantages:

1. Allows creation of multivariate terrains suitable for use in games, movies, animations, etc.;
2. Provides a flexible and powerful terrain generation process;
3. There is a large selection of tools and functions.

Disadvantages:

1. Complex to use and requires more time to master;
2. It's not free.

**Terragen:**

Advantages:

1. Provides realistic and detailed terrains;
2. Can generate very complex and aesthetic terrains;

3. There is a wide choice of textures and materials.

Disadvantages:

1. Requires a higher level of knowledge and skills;
2. Complicated to use and not free.

**L3DT:**

Advantages:

1. Allows generation of large and complex terrains;
2. Provides a wide selection of tools and functions;
3. It has built-in support for multiple file formats.

Disadvantages:

1. Complicated to use
2. It's not free

Comparison of the considered systems (Table 1):

*Table 1 - Comparison of the considered systems*

| system | price | graphical interface | used methods | Cross-platform support |
|---|---|---|---|---|
| Unity | Free/ Paid | yes | Perlin noise,<br>Vorni diagrams,<br>Heightmaps | Windows, Mac,<br>Linux,IOS,Android |
| Unreal Engine | Free/ Paid | yes | Perlin noise,<br>Simplex noise,<br>Vorni diagrams,<br>Erosin simulation | Windows, Mac,<br>Linux,IOS,Android |
| World Machine | Paid | yes | Perlin noise,<br>Fractal noise,<br>Erosion simulation,<br>Hydraulic erosion | Windows |
| Terragen | Paid | yes | Perlin noise,<br>Erosion simulation,<br>Hydraulic erosion | Windows,Mac |
| L3DT | Free/ Paid | yes | Perlin noise,<br>Fractal noise,<br>Erosion simulation,<br>Hydraulic erosion | Windows |
| Gaia | Paid | yes | Perlin noise,<br>Vorni diagrams,<br>Erosion simulation,<br>Hydraulic erosion | Windows |

All the programs discussed have their advantages and disadvantages, and choosing the best program for a particular project depends on many factors, such as user needs, budget, project requirements, etc. It is important to choose a tool that meets the needs of the specific user and project in order to generate high-quality terrain.

## CONCLUSION

After looking at some of the most popular 3D terrain generator programs such as Unity, Unreal Engine, WorldMachine, Terragen, L3DT, and Gaia, some conclusions can be drawn about what makes a program a good terrain generator.

All the systems discussed have certain characteristics that make them effective for generating 3D terrains. For example, Unity and Unreal Engine are good for generating terrains for PC games

and virtual reality, offering a lot of options for setting up and detailing the terrain. WorldMachine and Terragen are very suitable for creating realistic geographical formations, offering different tools to mix different types of noises and filters to achieve the desired results. L3DT is particularly useful for generating large terrains with a lot of detail, offering many options for setting up and controlling the terrain. Finally, Gaia is a good choice for generating terrains for Unity, offering easy integration with this game platform and many options for setting up the terrain.

Therefore, for a program to be a good pitch generator, it must have many pitch tuning and control options, as well as be able to generate different types of noise and apply different filters. It is also important to have options for layered texturing of the terrain, allowing for the addition of various elements such as vegetation, rocks, water surfaces and more. In addition, it is important that the program can create high-detail terrains, as well as be able to generate large terrains with small details, offering performance optimization options. It should be possible to export the created terrain in any of the file formats used in this subject area, as well as to import not only similar file formats, but also information from some known graphic formats representing information from this subject area (e.g. relief map in jpg-format, graphically represented objects objects such as trees, rivers, lakes, stumps, caves, cars, etc.). The generator must be able to work in real time, ie. – if the user is playing a game, he should be able to move in any direction without interrupting and delaying the generated terrain.

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